Catalogue of American Amphibians and Reptiles.

Krupa, James J. 1990. *Bufo cognatus*.

Bufo cognatus Say
Great Plains Toad

Bufo cognatus Say in James, 1823:190. Type-locality, "The alluvial fans of the [Arkansas] River," in Prower County, Colorado. Holotype, originally deposited in the original Philadelphia Museum; according to Baird and Girard (1853), it apparently was destroyed by fire (see Remarks).
Bufo musicus: Le Conte, 1855:430.
Incilius cognatus: Cope, 1863:50.
Bufo frontosus Cope, 1866:301. Type-locality, "The valley of the Colorado [River] from Fort Mojave to Fort Yuma." No information was provided on the deposition of the type-specimen. The description resembles both this species and *B. woodhousii.*
Bufo lentiginosus frontosus: Cope, 1875:29. Ellis and Henderson (1915) included this name as a synonym of *B. cognatus.*
Bufo lentiginosus cognatus: Cope, 1875:29.
Bufo dipternus Cope, 1879:437. Type-locality, "On the plains... of northern Montana...north of the Missouri river east of Fort Benton." This specimen was a juvenile *Bufo cognatus* that lacked the distinctive cranial crests. Type specimen not known to exist (Kellogg, 1932).
Bufo terrestis: Brocchi, 1882:77. See Remarks.
Bufo lentiginosus woodhousii: Stejneger, 1893:221. See Remarks.
Bufo cognatus cognatus: Camp, 1915:331.

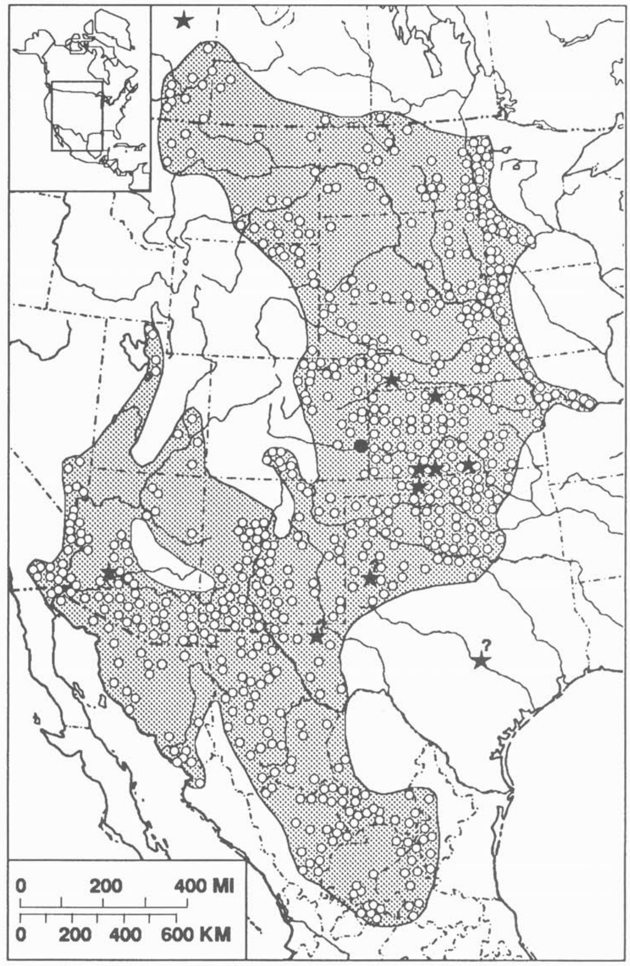
• **Content.** No subspecies are recognized (see Remarks).

• **Definition.** This species is a member of the *Bufo cognatus* species group (Blair, 1963; Tihen, 1962a). Adult snout-vent lengths range from 47 to 103 mm for males and 49 to 115 mm for females. The body is large and broad with the dorsum covered by numerous, small tubercles. The intraorbital space is narrow; intranasal space is wider than intraorbital space and snout length is equal to or less than length of eye. The parotoid glands are prominent and ovoid in shape, extending obliquely and posterio-laterally from directly behind the eyes. The cranial portion of these glands is in contact with the cranial crests. A large, bony boss covers the prefrontal region from the anterior portion of the orbit to the nostril. The two cranial crests are distinct and posteriorly diverge from the boss to form a "V"-shape between the eyes. The dorsal coloration varies from grey, brown, brownish-yellow, to the typical greenish hue. Commonly, large dorsal blotches are paired and irregularly shaped; they can be bordered by a band of black that in turn is bordered by a second cream-colored or white band. Smaller spots are often found on the sides and are broken into vermiculations. A mid-dorsal stripe is sometimes present and is typically faint but occasionally distinct. Green spots occur on the legs. The venter is lightly colored and, rarely, spotted. Males have a light-colored throat flap that covers a black vocal sac, which is sausage-shaped when inflated. The hind foot has two dark metatarsal tubercles with dark edges; one is much larger than the other. Toes are webbed and deeply indented; the femur is short. Males have a cornified area on the first digit.

The call is a loud, metalic-sounding trill. Call duration is quite variable, but lasts 25 sec on average with intercall intervals of approximately 10 sec. The dominant frequency can range from 1900 to 2600 Hz and is influenced by body size. Pulse rate ranges from 10 to 19 pulses per second and is temperature dependent.

• **Descriptions.** Descriptions of adults are in Burt (1931), Harlan (1827), Smith (1934), Storer (1925), and Wright and Wright (1942). Other descriptions are of tadpoles (Altig, 1970, 1987; Bragg, 1936, 1937b; Smith, 1946) and eggs and embryos (Bragg, 1937a, c). Call descriptions are in Bragg (1950d), Smith (1934), Ortenberger and Ortenberger (1926), and Dickerson (1906). Additional information on call characteristics is in Krupa (1989, 1990) and Sullivan (1983a).

• **Illustrations.** The first available illustrations include a color lithograph (Holbrook, 1842), a color drawing (Dickerson, 1906); and ink drawings (Baird, 1859; Baird and Girard, 1853; Cope, 1889).



Map. Distribution of *Bufo cognatus*. Solid circle indicates the type-locality, open circles represent localities from literature and museum records. Stars represent fossils; those with question marks indicate fossils that could be of *B. cognatus*, *B. speciosus*, or a recent ancestor.

Other illustrations include: color drawings of adults (Conant, 1975; Stebbins, 1985); color photographs of adults (Behler and King, 1979; Blair, 1972a); black and white photographs of adults (Bailey, 1944; Blair, 1959; Cook, 1966; Smith, 1934); and drawings of transforming tadpoles (Bragg, 1937b), tadpoles (Bragg, 1936), tadpole mouthparts (Bragg, 1936; Smith, 1946), eggs (Bragg, 1936; Livezey and Wright, 1947), cytological stages (Bragg, 1939c; 1939d), and embryological stages (Bragg, 1938b). Blair (1972a:366) provided a photograph of chromosomes. Bogert (1958) included a recording of the call, and a recording is available from the Missouri Department of Conservation (1985, Talking toads and frogs poster: Narrative and calls, P.O. Box 180, Jefferson City, Missouri, 65102-0180).

• **Distribution.** *Bufo cognatus* ranges from central Missouri, western Minnesota, and Iowa westward to central Montana and southeastern California and Nevada, and from southern Manitoba to Alberta southward in Mexico to Aguascalientes and San Luis Potosí. Kellogg (1932) mentioned its occurrence in San Pedro, Nayarit, but did not indicate deposition of a voucher specimen. Erroneous locality records have been reported for "Red River" and "Pole Creek," Arkansas (e.g., Cope, 1889; Kellogg, 1932; Yarrow, 1883; see Remarks). This species is found throughout the grasslands from short- to tall-grass prairie. In the western and southern portion of its range, it is found in mesquite grasslands, desert riparian associations, and desert scrub. It commonly occurs at elevations up to 1800 m and in the San Luis Valley of Colorado as high as 2400 m (Hahn, 1968).

Distributional literature for the United States is as follows: Arizona: Lowe (1964); California: Glaser (1970), Grinnell and Camp (1917), Linsdale (1936); Colorado: Hammerson (1982); Iowa: Bailey (1944); Kansas: Collins (1982); Minnesota: Breckenridge (1977);

Missouri: Johnson (1987); Montana: Black (1971); Nebraska: Lynch (1985); Nevada: Linsdale (1940); North Dakota: Wheeler and Wheeler (1966); Oklahoma: Bragg and Smith (1943); South Dakota: Fishbeck and Underhill (1960); Texas: Dixon (1987); Utah: Tanner (1931); Wyoming: Baxter and Stone (1980).

Cook (1984) provided a distribution map of this species in Canada. Literature for provinces is as follows: Alberta: Lewin (1963), Logier (1931), Moore (1953); Manitoba: Preston (1986); Saskatchewan: Cook (1960), Secoy and Vincent (1976).

Morafka (1977) provided a distribution map of this species in the Chihuahuan Desert; this map is the most comprehensive available for Mexico. Ferrari-Pérez (1886), Kellogg (1932), Riemer (1955), Smith and Taylor (1948), and Taylor and Smith (1945) provided localities for several Mexican states. Other distribution literature is as follows: Aguascalientes: Anderson and Lidicker (1963), Banta (1962), Chrapliwy et al. (1961); Baja California: Smith and Taylor (1948); Chihuahua: Chrapliwy and Fugler (1955), Domínguez et al. (1974), Firschein (1950), Smith et al. (1963), Van Devender and Lowe (1945); Coahuila: Chrapliwy et al. (1961), Dunn (1934), Liner et al. (1977); Durango: Webb (1984); Nuevo León: Treviño-Saldaña (1978); San Luis Potosí: Garman (1887), Taylor (1952); Sinaloa: McDiarmid et al. (1976); Sonora: Burger and Hensley (1949), Savage (1954), Smith and Hensley (1958).

• **Fossil Record.** Fossil *B. cognatus* are known from several sites dating from the middle Pliocene to the late Pleistocene (Eshelman, 1975; Holman, 1971; Tihen, 1962b, 1972). Specimens also were recovered from the Post-glacial Climatic Optimum in Canada (Bayrock, 1964). Numerous specimens exist that could be *B. cognatus*, the closely related *B. speciosus*, or possibly an ancestral form of these two species (Gehlbach and Holman, 1974; Holman, 1969; Mecham, 1959). Separation of the two extant species requires the presence of sacral vertebrae, which are lacking from several fossils.

• **Pertinent Literature.** A tremendous body of literature is available on this species, partially the result of availability for experiments due to its abundance and wide distribution, but also because bufonid evolution has received extensive consideration. Furthermore, this species is of interest for its abundant adaptations to semi-arid environments.

Numerous studies have considered phylogenetic and evolutionary relationships (Blair, 1956, 1962, 1963; Cei et al., 1968, 1972; Guttman, 1972; Low, 1972; Martin, 1972; Maxson, 1984; Maxson et al., 1981; Rogers, 1972, 1973a, 1973b). Other studies of similar theme include laboratory hybridizations (W. F. Blair, 1959, 1961); natural hybridizations (A. P. Blair, 1955; W. F. Blair, 1972b; Bragg, 1939a; Brown and Ewert, 1971; Conant, 1965; Cook, 1983); gene expression of creatine kinase (Buth et al., 1985); isolating mechanisms (Lowe, 1954); karyotypes (Bogart, 1972; Cole et al., 1968); and parotoid gland secretions (Hunsaker et al., 1961; Porter and Porter, 1967; Wittliff, 1962).

Morphological studies have addressed adipose tissue (Wygoda et al., 1987), the ear (Wever, 1985), histology of meninges (Palay, 1944), melanism and color pattern variation (Bragg, 1957, 1958), osteology (Martin, 1973; Tihen 1959, 1962a), ovaries (Clarke and Bragg, 1950), respiratory morphology (Bieniak and Watka, 1962; Czopek, 1965), size range (Bragg, 1950a), structures for sound production (Martin, 1971), tadpole morphology (Bragg, 1947), and testicular structure (Blair, 1972c).

Studies addressing development include DNA and developmental rate (Bachmann, 1972), larval stage duration (Bragg, 1939b; Gates, 1957; Hahn, 1968; Strecker, 1910), embryology and development (Bragg, 1937c, 1938b, 1939c, 1939d; Bresler, 1954), metamorphosis (Bragg, 1937b), and postmetamorphic growth rates (Bragg and Weese, 1950).

Physiological studies have addressed acid-soluble phosphates (Hazard and Hutchison, 1982), anoxia (Armentrout and Rose, 1971), critical thermal maxima (Paulson and Hutchison, 1987a), heat stress and thermal tolerance (Ballinger and McKinney, 1966; Brattstrom, 1963, 1968; Paulson and Hutchison, 1987b; Schmid, 1965, 1969; Zweifel, 1968, 1977), gas exchange and surface area relationships (Hillman, 1976; Hillman and Withers, 1979; Hutchison et al., 1968; Whitford and Meltzer, 1976; Withers and Hillman, 1983), lipid and polysaccharide storage (Anderson, 1967; Long, 1987), melanotropic activity (Hadley et al., 1985), neural mechanisms for unclasping behavior (Schmidt, 1974), osmotic tolerance (McClanahan, 1964), oxygen consumption and activity level (Seymour, 1972), oxygen dissociation (de Luque, 1972), phototaxis (Jaeger and Hailman, 1973), response to ultraviolet radiation (Taylor and Duerr, 1963), systemic blood flow (Hillman and Sommerfeldt, 1981), toxins (Daly

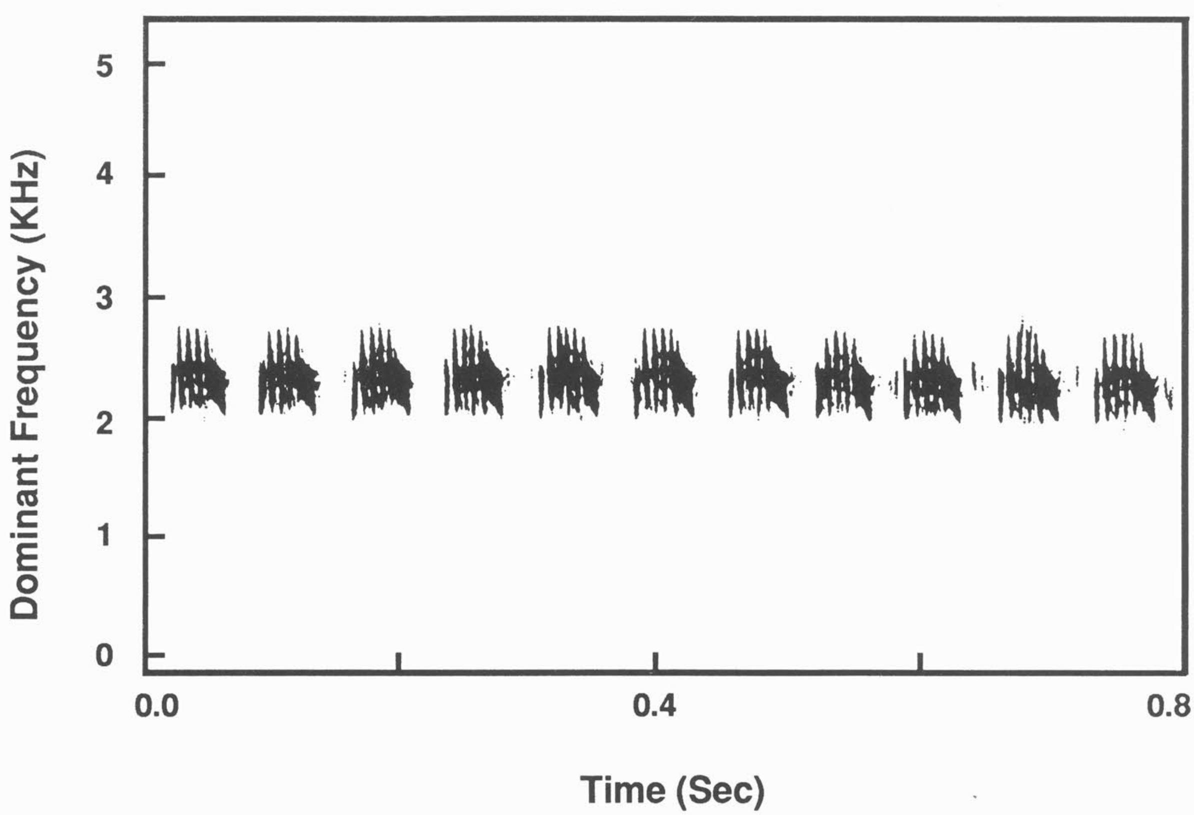


Figure 1. Audiospectrogram of a segment of an advertisement call of *Bufo cognatus;* Norman, Cleveland County, Oklahoma, 14 May 1986; snout-vent length 80 mm, body temperature 18°C..

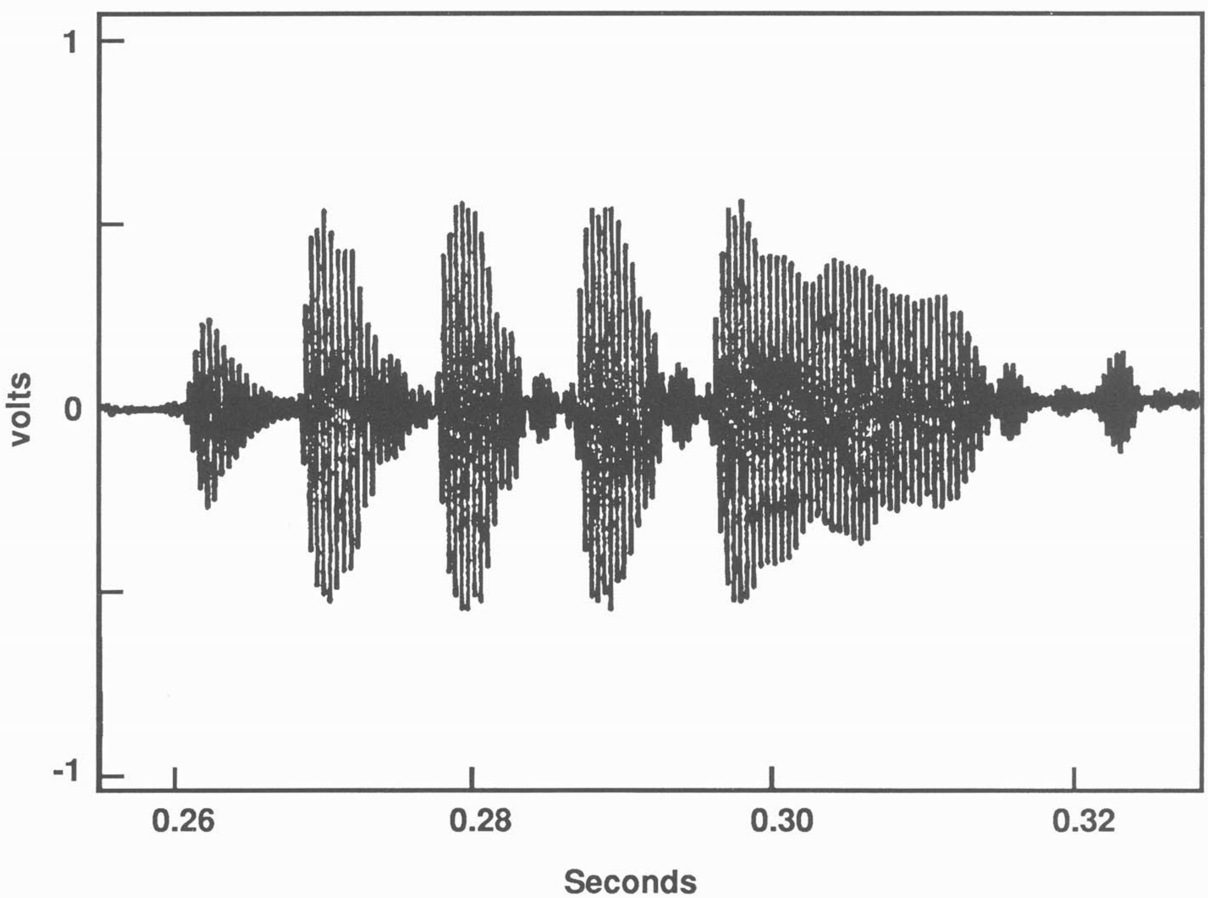


Figure 2. Waveform graph of a single pulse from the call shown in Figure 1.

and Witkop, 1971), vision (Ingle, 1976), and water storage, absorption, and dehydration tolerance (Hillman, 1980; Hillyard, 1976; Ruibal, 1962; Shoemaker, 1965; Walker and Whitford, 1970; Yokota and Hillman, 1984).

A wealth of literature addresses general behavior, ecology, and natural history (Bragg, 1937a, 1938a, 1940, 1941, 1942a, 1942b, 1945, 1946, 1950b, 1950c, 1950d, 1960a, 1960b; Bragg and Smith, 1942, 1943; Bragg and Weese, 1950; Kauffeld, 1943; Krupa, 1986b; King, 1932; Klauber, 1934; Smith and Bragg, 1949; Woodward, 1983). Other studies discuss activity patterns and climatic conditions (Creusere and Whitford, 1976), chorus configuration (McAlister, 1958), communication and call characteristics (Bogert, 1960; Krupa, 1989, 1990; Sullivan, 1983a), desert adaptations (Blair, 1976), digital trepidation (Bumzahem, 1953), economic value (Bragg, 1943; Klauber, 1934), fertilization efficiency and fecundity (Bragg, 1937a; Bragg and Bresler, 1950; Krupa, 1986a, 1987, 1988), habitat preference and distribution (Grenot et al., 1977; Tester et al., 1965; Timken and Dunlap, 1965), learning and taste aversion (Ribeiro, 1989), mating behavior and juvenile social behavior (Bragg, 1942a, 1960a; Bragg and Brooks, 1958; Brown and Pierce, 1967; Krupa, 1987, 1989; Sullivan 1982, 1983a, 1983b), monetary value (SSAR, 1989), multivariate analysis of distribution (Fischer, 1968), parasites and bacterial infections (Brooks, 1976; Kuntz 1940; Trowbridge and Hefley, 1933; Ulmer, 1970; Ulmer and James, 1976; Shively et al., 1981), predators (Jense and Linder, 1970; Kilgore, 1969), seasonal movements (Ewert, 1969), stomach contents, feeding and ecological energetics (Dimmit and Ruibal, 1980; Fair 1969; Hartman, 1906; Little and Keller, 1937), and zoogeography (Maxson, 1984; McCoy, 1984).

• **Remarks.** Some confusion exists about the fate of the type specimen. Baird and Girard (1853) reported that it was destroyed by fire, while Kellogg (1932) reported that the specimen was sold in 1850 and may have been part of the P. T. Barnum "American Museum" that was destroyed by fire in 1865. The surviving "Boston Collection" was eventually acquired by Harvard, although the type specimen does not appear in the vertebrate collection.

Two noteworthy cases of misidentification exist in the literature. Brocchi (1882) listed *Bufo terrestris* as a member of the Mexican herpetofauna. The description is of a specimen with cranial crests that unite anteriorly. The only Mexican species that fit this description are *B. cognatus* and *B. woodhousii*. Unfortunately, neither of Brocchi's descriptions of color and pattern for either *B. cognatus* or this *B. terrestris* fit typical *B. cognatus* color pattern. Also, Stejneger (1893) reported a specimen of *Bufo lentiginosus woodhousii* for Nevada that was in fact *B. cognatus* (see Linsdale, 1940).

Camp (1915) described *Bufo cognatus californicus* as a new subspecies, distinguishing it from James's (1823) type specimen (*Bufo cognatus cognatus*). Myers (1930) recognized these as separate species (*B. californicus* [= *B. microscaphus*] and *B. cognatus*). No subspecies of *B. cognatus* have been recognized since that time.

The "Arkansas" localities are from the Marcy Expedition of 1849 (Baird, 1859). Based on Warren's (1859) map illustrating the route of the expedition, these records undoubtedly are from the Red River in south-central Oklahoma.

• **Etymology.** The name *cognatus* is Latin and means related or kindred, a reference to Thomas Say's observation that this species generally resembles *B. musicus* [= *woodhousii*] and *B. fuscus* [= ?] in appearance and to *B. musicus* in habitat (James, 1823).

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Figure 3. Calling male *Bufo cognatus* from Norman, Oklahoma.

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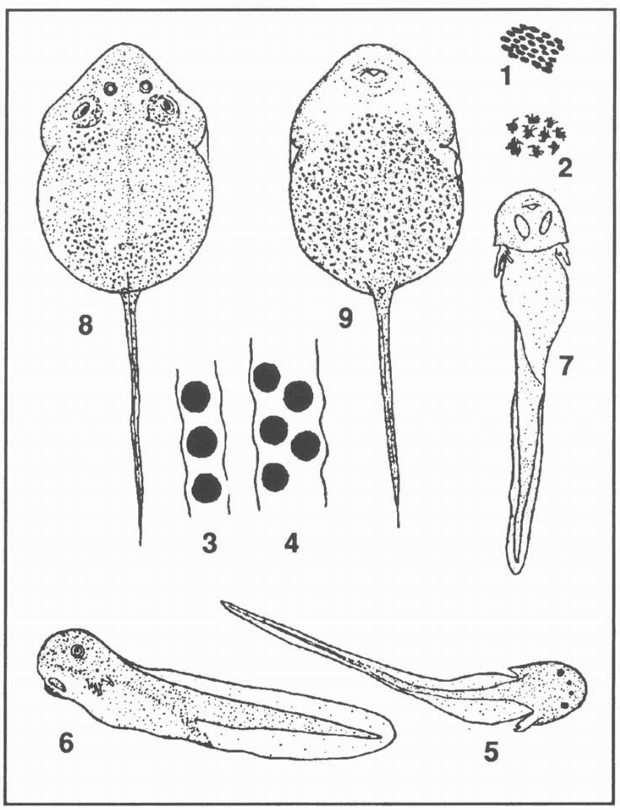


Figure 4. Illustrations of various aspects of *Bufo cognatus* development, from Bragg (1936): (1) melanophores from the skin of an 8 mm (total length) tadpole; (2) chromatophores from an 8 mm tadpole; (3) portion of single egg string; (4) portion of double egg string; (5) dorsal view of a 5.2 mm tadpole; (6) lateral view of a 5.2 mm tadpole; (7) ventral view of a 5.5 mm tadpole; (8) dorsal view of an 8 mm tadpole; and (9) a ventral view of an 8 mm tadpole.

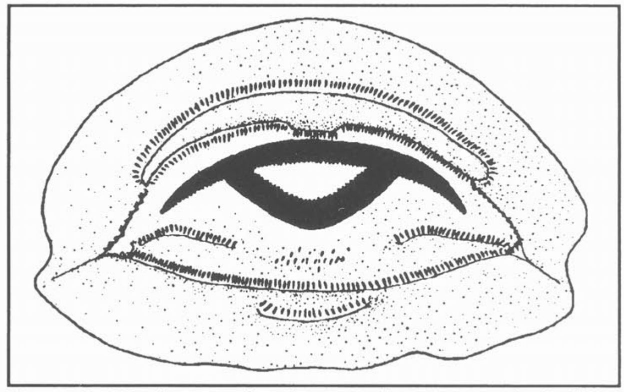


Figure 5. Mouth parts of a 25 mm *Bufo cognatus* tadpole (from Bragg, 1936).

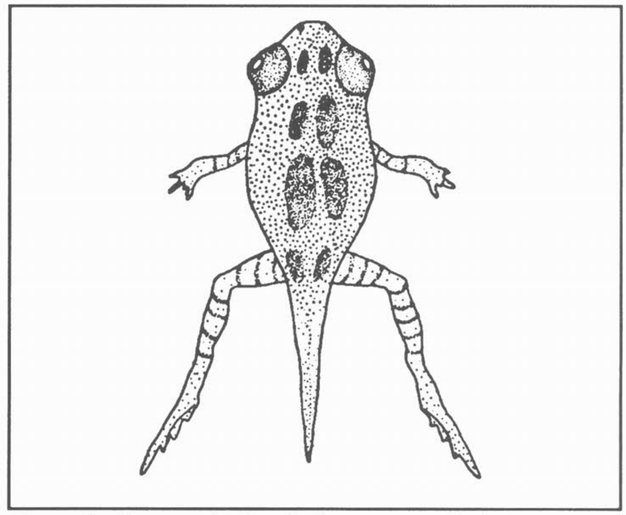


Figure 6. Metamorphosing *Bufo cognatus* tadpole 21 mm total length, 11 mm snout-vent length (from Bragg 1937b).

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